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Managing five paradoxes of knowledge exchange in networked organizations: new priorities for HRM?

Christopher Mabey and **Shasha Zhao**, Middlesex University Business School, The Burroughs, London NW4 4BT, UK

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The life-blood of most organizations is knowledge. Too often, the very mechanisms set up to facilitate knowledge flow militate against it. This is because they are instituted in a top-down way, they are cumbersome to manage and the bridges of trust fail to get built. In their thirst for innovation, the tendency is for firms to set up elaborate transmission channels and governance systems. As a result, staff are drowned in a deluge of mundane intranet messages and bewildered by matrix structures, while off-the-wall ideas and mould-breaking insights are routinely missed. Added to this is the challenge of operating across professional, cultural, regional and linguistic boundaries, where ways of sharing knowledge differ markedly, even within the same project team. Drawing upon extensive research with scientists in the ATLAS collaboration (a high-energy particle physics experiment comprising 3,500 scientists from 38 countries), we explore five paradoxes associated with knowledge exchange in global networks. Each paradox leads to a proposition which takes the theory and practice of knowledge management in a fresh direction. We conclude by outlining a number of HRM priorities for international knowledge-intensive organizations.

Contact: Professor Chris Mabey, Middlesex University Business School, The Burroughs, London NW4 4BT, UK. Email: c.mabey@mdx.ac.uk

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INTRODUCTION

Exploiting maximum benefit from multi-agency and multi-national knowledge networks remains a high priority of private firms and public agencies alike. The ATLAS collaboration is working at the pioneering cusp of experimental particle physics; it relies upon the highly sophisticated Large Hadron Collider equipment and teams of physicists, technologists and support staff operating in 175 national Institutes in 38 countries, but mainly at the hub of activities in CERN near Geneva. While the ATLAS collaboration is in some ways a unique knowledge-intensive enterprise, it offers some fascinating insights on effective knowledge exchange across non-hierarchical global networks. Between 2010 and 2013 a research team observed many formal and informal gatherings of the ATLAS collaboration and conducted 76 interviews with scientists in Europe and China. Preliminary analysis revealed that the sharing of precious know-how operates as an embedded (barely visible), path-dependent and patterned process (see Appendix). Here, for the first time, we stand back and reflect on the entire case and from this review we observe five intriguing paradoxes which challenge conventional ways of managing knowledge in the advanced knowledge economy.

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This paper contributes to theory and practice in two ways. First, by analysing knowledge exchange in a global R&D community, we begin to address a gap in current theorizing, where much of the work is still conceptual and/or tends to focus on MNCs (Tallman and Chacar, 2011; Choi and Johanson, 2012; Ferner *et al*., 2012; Kasper *et al*., 2013) or consultancies (Donnelly, 2008; Alvesson, 2011; Kinnie and Swart, 2012; Swart and Kinnie, 2013). This also addresses a call by Champalov *et al*. (2002) for more studies of scientific, inter-organizational collaborations as objects of enquiry and provides fresh understanding of the way HRM can promote effective knowledge exchange in networked organizations, a disaggregated organizational form which is increasingly favoured across all sectors (Felin *et al*., 2009). Second, we take issue with an undifferentiated view of strategic knowledge, which regards it as inherently commodifiable and then assumes that, with well-chosen governance and HR mechanisms, dissemination will be swift and unhindered. Our analysis demonstrates several counter-intuitive features of knowledge exchange which challenge this current theorization of KM. The paper is structured in the following manner. In the next section we summarize a number of core dimensions arising from the knowledge management (KM) literature, before noting some key KM 'realities' which have so far been neglected. We then explore this gap in KM theory by discussing the nature of five paradoxes which surfaced in the study of knowledge exchange among ATLAS scientists. For each of these paradoxes we offer a theoretical proposition which highlights the counter-intuitive aspects of knowledge exchange. We hope this discussion contributes to KM theory and in the concluding section we outline a number of HRM priorities for those organizations whose success depends on the judicious surfacing and sharing of innovative knowledge.

WHAT DOES THE CURRENT LITERATURE ON KNOWLEDGE MANAGEMENT TELL US?

The field of knowledge management is extensive. By way of providing a conceptual context for this paper, some of the key theoretical considerations are briefly summarized below, together with contributions from the field of HRM.

Knowledge is a strategically important

The knowledge-based view of the firm (KBV) maintains that knowledge resources have the distinctive properties of heterogeneity and immobility, so utilization of knowledge becomes a way of creating a sustainable competitive advantage (Kogut and Zander, 1996; King and Zeithaml, 2003). In other words, KBV concerns two stages of operations: firstly, the increase in the stock of useful knowledge and secondly, the extension of its application. By doing so, knowledge becomes the essence of modern economic growth, particularly as modern organizations are likely to operate in the knowledge-intensive industries instead of labour-intensive (Ensign, 1999). Consequently, it is a priority of HR professionals to implement bundles of HRM practices that successfully attract, motivate and retain knowledge workers (Horwitz *et al*., 2003) and create conditions that encourage individuals' knowledge to be utilized at the collective level (Sparrow, 2006).

Tacit knowledge has a particular premium

In contrast to explicit knowledge which is expressed in words, data, numbers, and codified into symbolic forms such as documents and databases, tacit knowledge is personal, context-specific and hard to formalize and to articulate, often invisible to outsiders of a particular organizational context (Davis *et al*., 2005). Because tacit knowledge is more intuitive, elusive and emergent over time, it remains embedded within the fluid social structures of networks and organizations, so the HRM challenge of nurturing and utilising such mercurial knowledge

is quite different from KM in more hierarchical settings. Especially in the context of networked organizations, HRM seeks to encourage a more distributed style of knowledge exchange which is emergent and co-determined by a range of interdependent actors (Marion and Uhl Bein, 2001; Gronn, 2002). Knowledge transfer in informal networks is heavily dependent on social cohesion, continuity, and individuals' willingness and motivation to invest time and effort in sharing knowledge (Reagans and McEvily, 2003).

Knowledge exchange is context-specific

Knowledge is grounded in the experience and expertise of individuals, thus is enacted through the perspective of multiple 'knowers' in a firm (Tsoukas, 1996; Glazer, 1998; Orlikowski, 2002); knowledge entails scope and context (Von Krogh *et al*., 1996); specifically, knowledge is created and exchanged within an organizational context, which is closely tied to its external social environment. Swart and Kinnie (2013) point out that HRM approaches to knowledge assets have tended to be focus on *individual* HR practices designed to manage human capital: drawing upon data from 12 professional service firms they demonstrate that knowledge assets are, in fact, multi-dimensional and different *configurations* of HR practices deploy social and organizational capital to achieve effective knowledge exchange within and across the firms' boundaries.

The creation and utilization of knowledge is multi-phased

Kayes *et al*. (2005) draw upon Kolb's (1984) theory of experiential learning to describe the transformation of knowledge as proceeding through four stages: individuals involved in generating, gathering, organizing and acting on knowledge. Other authors, like Dyer and Nobeoka (2000), focus more on organizational routines as the essence of any organizational learning, with a regular pattern of interactions among firm members contributing to the exchange, recombination, or creation of specialized knowledge (Assimakopoulos and Yan, 2006). Perhaps most influential is the work of Nonaka (1995, 2001) who examines the knowledge exchange process by combining two dimensions, epistemology and ontology; on the one hand, the continual dialogue that exists between explicit and tacit knowledge which drives the exchange of knowledge and results in new ideas; on the other hand, human interaction which contributes to the amplification of knowledge through sharing. This takes place through four modes, each setting a different training and development/learning agenda for HRM.

Organizations require sophisticated knowledge management systems

The possession and understanding of knowledge resource is not enough, firms need to have appropriate management to utilize individually-held knowledge for sustainable competitiveness (Grant, 2000; Wensley and Verwijk-O'Sullivan, 2000; Wang *et al*., 2004). The central concern is creating and maintaining conditions for knowledge utilization and competitive advantage creation, to support the goals of the organization (Despres and Chauvel, 2000). To achieve this, internal mechanisms need to be in place including appropriate organizational structures, systems, facilities, cultures and channels, such as allocating knowledge managers, incentives for sharing knowledge and KM technologies (Demarest, 1997; Grant, 2000). Again, HRM has a pivotal role to play in establishing and sustaining these KM systems, either by focusing on specific HR interventions like the training of employees (Kase *et al*., 2009), learning from expatriates (Sparrow, 2006), appropriate reward systems (Minbaeva *et al*., 2003) and shared communication codes and channels or by a configuration of internally consistent HR practices (Lepak and Snell, 2007).

Knowledge management in international firms is especially challenging

As firms become more international in their reach, developing mechanisms and practices that facilitate knowledge sharing and the development of common mind-sets across diverse cultural boundaries becomes ever more crucial. While such infrastructural support and formal integrative mechanisms (Gupta and Govindarajan, 2000), as well as ICTs, may enable knowledge exchange in the face of spatial distance, this won't necessarily be productive manner without the astute use of HRM processes. Early mentoring, business visits and foreign transfers can act as valuable ways of achieving the exchange of non-codified knowledge because they facilitate the development of a common set of beliefs and values. The risk is that such mechanisms in international firms can lead to unwanted homogeneity where diversity of individuals is screened out (Kyriakidou, 2005). Lauring and Selmer (2012) found cultural and linguistic diversity among university staff led to more positive knowledge sharing than demographic diversity like age and gender. Thus. cultural distance can be re-framed as cultural friction (Shenkar, 2012) and, in an international business setting, this has been defined as "the extent to which two or more entities, such as organizations, units, teams, groups, and individuals from different countries culturally resist (i.e., think or act in opposition, shaped by implicit beliefs and tacit values) with one another in real contact or interactions over the course of international business activities or transactions" (Luo and Shenkar, 2011: 2). Patently, if the dysfunctional aspects of cross-cultural knowledge exchange – like interpersonal conflict, miscommunication, slower decision-making and lack of cohesion – can be minimised, the opportunities for deeper learning arising from constructive friction are immense for an international enterprise. This applies to the organization as well as to individuals (*e.g.* Tsang, 2001; Suutari and Taka, 2004).

Undoubtedly, the literature briefly reviewed above contributes a great deal to our understanding of the importance of effective knowledge exchange and how HR professionals enable it to take place in and across organizations. However, it is the contention of this paper that current theorizing neglects some of the 'realities' of knowledge exchange. Knowledge transfer/exchange between individuals is not automatic because there is a system in place; rather, it is a shared process in which participants are constantly re-evaluating trust, making sense of social and institutional cues and (re-)constructing their own meanings of available knowledge (Howells, 2012). Social relations and power-plays within and between organizations, often distort or dilute directives from appointed leaders or confound the prescriptions of highly rational management systems (Donnelly, 2008; Seba and Rowley, 2010).

The flaw inherent within many KM theories and, as a consequence, many HR efforts to facilitate knowledge exchange, is that they have a 'top-down', unidirectional feel to them; this is unlikely to create the conditions for an unfettered flow of knowledge, especially in a cross-cultural environment (Budwhar and Sparrow, 2003; Fenton O'Creevy, 2003). Longitudinal research on the efficacy of globally distributed teams in a US multinational by Baba *et al*. (2004) concluded that culturally-grounded cognitive differences about overall business models tend to persist; crucially, these contradictory perceptions lead to team members rejecting certain aspects of knowledge held by the other. These conceptual shortcomings arise due to a tendency to objectify knowledge as something to be captured and categorized; the premise being that knowledge can be separated from the knower. This mind-set, characterized by the term *knowledge assets* (borrowed from the accounting discipline) leads researchers to place emphasis upon choosing appropriate governance systems (Ivory *et al*., 2007; Easterby-Smith *et al*., 2008) in order to positively impact organizational performance, (Gonzalez-Padron *et al*., 2010) or competitive advantage (Easterby-Smith and Prieto, 2008). Understandably perhaps, the HRM literature has tended to follow this functionalist discourse (Baruch *et al*., 2013), with ever

more sophisticated attempts to identify the practices or bundles of practices that will best facilitate different KM priorities. This may be appropriate for some firms, but less so for the increasing number of disaggregated organizational forms and networked organizations (Felin *et al*., 2009), populated by knowledge workers with 'boundaryless' or portfolio careers (Kamoche *et al*., 2011).

The purpose of this paper is to offer specific guidance to those tasked with more effective knowledge exchange in and across organizations, especially non-hierarchical, networked organizations operating internationally. To do this we need to develop KM and HRM theory in a way which takes account of these realities and offers ways of handling them at an operational level. In the next section we draw upon findings derived from studies of scientists working on the ATLAS particle physics collaboration conducted between 2010 and 2013 (see Appendix for a more detailed account of the sample organization and research design). For the purposes of this conceptual review we reflect on five counter-intuitive features of KM which emerged from the totality of these data and recent literature. The propositions associated with each paradox serve to question the conventional wisdom of KM. We then propose ways of amplifying our theoretical understanding of knowledge exchange in networked organizations and offer guidance to HR specialists who have responsibility for managing knowledge and knowledge activists.

WHAT CAN WE LEARN ABOUT EFFECTIVE KNOWLEDGE EXCHANGE FROM ATLAS?

Paradox 1: the more knowledge is formally managed, the *less* likely effective knowledge exchange will occur

Knowledge activists with portfolio careers are typically highly motivated and autonomous individuals who resist close supervision and management control (Kamoche *et al*., 2011). Organizations often fail to leverage their tacit knowledge: important know-how remains untapped, career-minded individuals take it with them to the next job, competitive cabals dilute or sanitize what they are willing to share with external parties and project groups jealously hoard their knowledge assets. In each case, the collective benefit does not materialize and organizational learning is impaired (Bouty, 2000; Bosch-Sjitsema *et al*., 2011). The reason is that, far from being self-evident and easily classified (Alvesson, 2011), knowledge is actually a highly ambiguous, uncertain and controversial concept. This is especially the case for tacit knowledge (Styhre, 2004). In short, knowledge is not a commodity. Too many firms assess knowledge economically: "not by its truth-value but by its *exchange value*; that is, it is produced in order to be sold. It becomes subsumed within the flow of capital as part of the consolidation of consumerism within post-industrial societies." (Case *et al*., 2012: 356–7, emphasis in original). Given the precious nature of tacit knowledge and the autonomous agendas of knowledge workers – with possibly greater commitment to their profession than to their employer (Kinnie and Swart, 2012) – the inclination for competitive firms and international networks is to manage knowledge-flow tightly. Paradoxically this is counter-productive. A study of professional service firms illustrates this by elucidating the differing nature of commitment among knowledge workers (Swart *et al*., 2014): affective commitment to their team and profession and normative commitment to the organization enhance knowledge sharing behaviour; while continuance commitment to the client is negatively related to knowledge sharing because employees want to become client and industry experts and are therefore reluctant to share their knowledge with organizational colleagues.

A critical difference in ATLAS is that knowledge is not produced to be sold, but to solve. As we note: "Our study of ATLAS scientists at 'lab level' shows them to be adept at building cognitive capital, where shared mental schema and strong working relationships on a day-

to-day level allow for the fast uptake of important, intuitive knowledge" (Mabey *et al*., 2012: 2462). Their enthusiasm for and identification with the shared project is palpable. ATLAS scientists are fiercely individualistic, but three factors appear to facilitate knowledge flow. First, there is built-in interdependence so scientists remain loyal and committed to an transcendent goal which helps them rise above partisan interests; this structural modularity, which is a deliberate design feature of the overall experiment, means that no one part of the network can go it alone. Second, there is a noticeable absence of formal governance systems and corporate compliance procedures at ATLAS: professional peer pressure is enough to keep creative thoughts flowing. Third, and in contrast to the Swart *et al*. (2014) study cited above, there is an intrinsic commitment to a long-term legacy which will outlast most scientists' careers (see also Knorr-Cetina, 1995); this largely replaces the need for performance management and mitigates against an internally competitive 'quick wins' mentality, typical of many international firms.

Paradox 2: the more democratic knowledge-exchange is desired, the *more* intentional leadership is required

Any network operating with loose and flat structures, relying on high trust and mutually beneficial goals has the opportunity to benefit from the productive, sometimes serendipitous, exchange of knowledge: "Observation of the main cafeteria at CERN [the hub of the ATLAS collaboration] near Geneva, is testimony to this highly fruitful bazaar of knowledge-sharing" (Mabey *et al*., 2015: 495). Informal clusters gather at different periods of the day and night, deep in animated conversation. Ironically, this spontaneous exchange of tacit knowledge requires strong leadership to create an environment, an architectural space, where knowledge activists are drawn together to engage in the buzz of brainstorming (Fleming and Waguespack, 2007). Such an ethos does not happen by chance, nor can it be corporately mandated, but leaders such as the low-key and consultative Peter Jenni, who was spokesperson of ATLAS for 15 years from 1996, set the right tone. It would appear that a strong ethic of collaboration is set in motion and sustained; this being quite different from the conventional notion of the all-powerful leader who single-handedly directs the course of a corporation. In the loosely-coupled context of an organization, network or place, the notion of a larger-than-life transformational leader has little traction. The strength of leadership in knowledge intensive settings derives from its collective intent, helping to create a strong and shared ethical purpose across a wide range of constituent groups. We choose to call this intentional, or 'light-touch' leadership (rather than charismatic leadership, with its connotation of an authoritarian and/or heroic leadership style).

Such co-created leadership, based on a shared ethic, mitigate against any attempt by over-mighty individuals to galvanise followers around their own totalizing ideology (Tourish, 2013) and manipulate them into compliant patterns of behaviour (Case and Gosling, 2010), something which an earlier generation of ATLAS scientists had experienced (Taubes, 1986). Quite apart from these darker scenarios, it is highly unlikely that any one individual will possess all the knowledge necessary to lead, or direct the leadership in others, across complex and ambiguous organizational spaces (Gibney *et al*., 2009). In this context, the often quoted business aphorism: *if you can't measure it, you can't manage it*, should perhaps be replaced with: *if you can't let go, you can't lead*. This is not to say that leadership is *laissez-faire*. In their study of the ATLAS collaboration, Boisot *et al*. (2011) observe three dimensions of proactive but collaborative leadership which might equally apply to non-scientific, privately or publicly funded enterprises. The first is *intellectual* leadership which is necessary to foster a willingness and ability to take risks at a local level, not always easy in a methodical, highly-audited R&D environment; part of the skill here is framing the process of discovery in a way that is seen as

worthwhile to all members of the collaboration and by balancing the flow of knowledge, knowledge workers and finances between the headquarters and subsidiaries (in the case of ATLAS, between central activities at CERN and the 137 home institutes). Even in the well-resourced context of ATLAS, there is still competition for resources, so knowledge leadership is also called for at an *institutional* level to ensure that national funding is secured at the expense of competitor claims; this is done by creating an enabling culture to channel knowledge-flow toward a big-picture of societal gain that all can subscribe to. Infusing all of this is *political* leadership, which essentially amounts to managing the expectations and commitments of different constituents internally as well as stakeholders externally (including Governments who, in the case of science, are committing huge funds to experiments year on year). Our analysis of ATLAS shows that such know-how is not only the prerogative of those in formal leadership roles but invested in all members of the collaboration who use their political nous to develop their networks to improve collective performance on the one hand and personal career outcomes on the other (Wei *et al*., 2011).

Paradox 3: the more knowledgeable professionals are, the *less* likely they are able to lead

Organizations have a tendency to systematically *dis*able their professionals so that as they become more expert, knowledgeable and senior, they also become less likely to be good leaders. Why is this? First, there is a gravitational pull to cultivate those with specialist expertise in a narrow professional field rather than those who are able to move across disciplinary silos as so-called boundary scanners (Janowicz-Panjaitan and Noorderhaven, 2009). Second, most professions, including scientific networks, rightly emphasize reliance on trusted sources; but this can lead to conservatism and an unwillingness or inability to consider deviant options.... which is where innovation often arises. Third, many networks, especially academically inclined ones, have a tendency to become myopic in valuing knowledge for its own sake and its theoretical contribution; knowledge activists are trained to apply reflection to the analysis and communication of observed events *rather than to their application*, so relinquishing influential leadership to external entrepreneurs who are more adept at exploiting knowledge opportunities. To our surprise, we found very little appetite among ATLAS scientists for technology transfer arising from their pioneering science despite the wealth of precious applications that others were making in the fields of digital radiography, neural biology, software technology arising from ATLAS work.

Fourth, most professions place immense effort into rigorous procedures, peer-reviewed quality and validated outputs. Little time is left or devoted to how these are achieved. The emphasis is on *know-what* in the form of cross-validated outputs, rather than on *know-how*, namely the mercurial social processes – like team dynamics, risk-taking, socialization and mentoring – that combine to produce creative outputs (Newell *et al*., 2001a). Finally and perhaps unwittingly, most professions and organizations reward solo success (promotions, Nobel prizes, professional recognition, individual qualifications) at the expense of team efforts and collaborative commitment. Despite their democratic decision-making and flat structures, in ATLAS we found so called soft knowledge or 'socialware' (Nicolini *et al*., 2007), like people and project management and interpersonal skills, to be largely tacit rather than widely diffused (Ihrig and MacMillan, 2013). For example: "Newcomers arriving at CERN…are socialized into strong norms and inducted into an informal code of conduct. This has obvious benefits in terms of facilitating inclusion and contribution. By the same token, it creates difficulties for those scientists not geographically proximate to the R&D hub at CERN" (Mabey *et al*., 2015: 496). In other words this expertise was present but located in pockets and not widely disseminated

or leveraged. This was due to a combination of disabling factors; lack of face to face interaction with opinion leaders at HQ, linguistic and cultural inhibitors to swift knowledge exchange and disrupted internet connections to more remote partners. Taken together these factors represent a risk for any organization intent on effective knowledge exchange.

Paradox 4: the more pervasive the technologies for knowledge exchange, the *more* isolated knowledge specialists can become

Each specialist team at ATLAS works on a comparatively small feature of the experiment and is dependent on many other teams for the cross-flow of scientific knowledge, which comprises both tacit, practice-based knowledge and codifiable information. To facilitate the transfer of these two equally important and complementary categories of scientific knowledge across borders are a myriad of 'knowledge' management tools, intranet and other ICT platforms (it is notable, for example, that the world-wide-web originated at CERN in 1990 by Tim Berners-Lee was an ingenious means to aid global communication). Immersed in 24/7 extensive and pervasive access to knowledge, ATLAS has to work hard to prevent the fragmented and specialized nature of this knowledge from leading to the isolation of individual knowledge workers. Tacit knowledge tends to be idiosyncratic and experiential, embedded in a specific context and not readily articulated as data or language (Nonaka and Takeuchi, 1995; Davis *et al*., 2005). Instead, this less codifiable and less ICT-enabled knowledge exchange requires much more humanistic approach, with a heavy reliance on socialization (Nonaka *et al*., 2001). As we discovered with the ATLAS respondents: "When asked about moments when knowledge is created or shared, most insisted on the importance of informal encounters, such as coffee breaks and *ad hoc* exchanges, rather than more formal or planned ones" (Mabey *et al*., 2012: 2458).

Indeed, there is evidence to suggest that mechanisms like the intranet can paradoxically *inhibit* knowledge exchange; in their study of a global bank, Newell *et al* (2001b: 97) noted that: "ironically, the outcome of intranet adoption was that, rather than integrate individuals across this particular organization, the intranet actually helped to reinforce the existing functional and national boundaries with 'electronic fences'." Commenting on the knowledge economy more generally, Howells (2012) offers several reasons for this potential isolation. The first is social. He notes that the span of peers with whom such knowledge workers can interact becomes increasingly narrow, and not necessarily close geographically, as specialization intensifies; this leads to relational isolation. Second, technically, the rapid move towards division of labour in complex R&D leads to a so-called *dendritic* evolutionary pattern of development, where individuals at the frontier edge of knowledge domains find themselves unable to meaningfully exchange with those at the frontiers of other knowledge domains, due to earlier radical breaks in the way knowledge in their field evolved. The third reason is cognitive: the sheer complexity of scientific and technical problems, means that very few individuals possess an overview of how all the parts fit together, leading most knowledge workers marooned in narrow specialisms, with only a sketchy understanding of the overall picture. This leads Howells (2012: 1014) to conclude: "Unless very fortunate in being in places where there is … specialized concentration, advanced knowledge workers have never been better connected 'information-wise', but never more isolated 'knowledge-wise' ".

Furthermore, because knowledge is 'inextricably' tied to a specific context (e.g. national and/or cultural), the idiosyncratic nature of knowledge leaves room for numerous problems of both access and interpretation (Roberts, 2000a, 2000b). For ATLAS scientists, we found that; "ICTs underscore all they do and produce and the Chinese scientists were quick to point out

the disabling effects when Internet connections with CERN were disrupted or web platforms were difficult to navigate.…Face-to-face communications in conjunction with technology-mediated interactions provide a basis for 'virtual continuities' which are crucial to ATLAS, a project which relies on virtual working with fellow physicists around the world" (Mabey *et al*., 2015: 496). In short, when it comes to the effective exchange of especially tacit knowledge good technology is necessary but not sufficient.

Paradox 5: the more informal that knowledge exchange is, the *more* likely it is that discrimination will occur

As in any international organization or network, the management of *explicit* knowledge is relatively straightforward in ATLAS: "the project is firmly embedded in a robust legal, administrative and technological environment … [which] … provides essential services such as purchasing and contracting, staff-administration, safety management, utilities and other physical support" (Global Science Forum, 2010: 20). However, knowledge exchange within this "project" at laboratory level is largely tacit; even though the ATLAS scientists come from diverse backgrounds, they claim to have developed a common language and understanding of the world, with their affinity for physics overcoming cultural and linguistic barriers. As noted above, newcomers to the collaboration are socialized into strong norms and inducted to an informal code of conduct. But herein lies a further paradox. The more self-selecting and less centrally choreographed the processes of inclusion and interaction, the more discriminatory such filters *can* become. The potential danger is that, far from legitimizing and celebrating cultural, gender and ethnic diversity across institutional and social networks, such informality can actually have the opposite effect. It can reinforce social boundaries, homogenize collective behavior and perpetuate cultural conformity (Kyriakidou, 2005; Frenkel and Shenhav, 2006); all inimical to the innovation-seeking enterprise.

In our study, we found some evidence of this inadvertent discrimination. For example, our multi-discourse analysis revealed that: "the assumption that socio-politically *all actors have equal access* to resources for knowledge exchange is … suspect because a more critical reading of the case tells us that the amount, nature and flow of knowledge leadership is dependent upon many socio-cultural factors, not least the prosperity of one's host-Institution" (Mabey and Nicholds, 2015: 49). The very self-selection of this type of learning occasionally led to the marginalizing and exclusion of 'out-groups', not just those physically distant and therefore unable to participate in the exchange of tacit knowledge but also those on site but barred for more subtle reasons from such discussions. Readiness to conform to CERN's sub-cultural norms, willingness to socialize after hours (which has a gender dimension) and being fluent in English language were among such reasons. This echoes the observation that, despite the profusion of knowledge technologies, knowledge often remains "stubbornly localized around the comparatively small number of highly skilled knowledge workers engaged in high orientation networks … we still live and work in narrow social networks" (Howells, 2012: 1014). This also resonates with studies of MNCs where headquarters (in our case, CERN) tends to exert power over meaning by shaping 'corporate' culture and, "codes of practice and standard operating procedures … then become institutionalized" (Ferner *et al*., 2012: 9). This notion of what we might call institutional distance, poses a challenge for the less-hierarchical domain of global networks.

THEORETICAL IMPLICATIONS

The theoretical contribution of this paper rests in the identification of five knowledge management paradoxes based on empirical arising from a global R&D network, the ATLAS

particle physics collaboration. We recognize that this is just one case, and indeed an outlier case, given its unique position as the world's largest R&D collaboration. We also acknowledge that our data is very partial, based as it is on a small fraction of scientists and their meetings over a three year period. The discourse and method chosen to examine knowledge exchange in this setting was largely interpretive, and while this reveals richness it cannot claim to be generalizable. Despite these limitations, we believe the exploratory nature of this paper has uncovered some features of knowledge exchange which counter current KM models. We contend that collectively: they address more adequately the realities of knowledge and knowledge exchange in organizations generally; they contribute to a more robust model of HRM in knowledge-based organizations; and they suggest fresh and intriguing lines for future research enquiry.

First, while current literature demonstrates that organizations of all types (such as research institutions, universities, and private firms) benefit from extensive knowledge management (Grant, 2000; Teece, 2000; Wang *et al*., 2004) supported by appropriate IT management systems, this paper conceptualizes the counter-productive side of over-management when it comes to sharing tacit knowledge. Second, while KM theorists suggest that flattened organizational structure will lead to greater knowledge transfer, we contend here that this process is by no means inevitable and that intentional leadership based on a collaborative ethic is necessary for the creation of a 'shared' space to promote informal knowledge exchange. Third, rather than assuming that those gaining seniority and influence in knowledge intensive environments will be adept at sharing their specialist knowledge, attention needs to be given to their ability to lead effectively as well as to institutional mechanisms which will encourage collaborative leadership style. Fourth, while existing literature points to the usefulness of technologies for promoting knowledge activities (Corso and Paolucci, 2001; Edwards *et al*., 2005), this paper suggests that the benefits of IT management strategies should not be taken for granted; at least as important is promoting socialization among users with greater levels of freedom to facilitate knowledge exchange (Sparrow, 2006). Finally, while the common consensus suggests informal socialization promotes better knowledge exchange, this paper counters this assumption; the more informal the knowledge-sharing relationships are, the more likely that some groups (especially those that are geographically distant) will miss out on vital knowledge. In short, we argue that the generation of truly innovative, creative and productively deviant knowledge exchange must be considered a counter-intuitive process, calling for some fresh interventions by HRM in knowledge-intensive organizations if maximum value is to be created.

PRACTICAL IMPLICATIONS FOR EFFECTIVE HRM IN KNOWLEDGE-INTENSIVE ORGANIZATIONS

We have seen that conventional approaches to knowledge leadership and HRM have less currency in networked organizations in the advanced knowledge economy. Our study of scientists in the ATLAS collaboration reveals a number of paradoxes concerning KM in such organizations. At first sight, this may appear to complicate and confuse the role of HR specialists in promoting knowledge exchange. But according to Smith and Lewis (2011: 395): "in contrast to contingency theory, a paradox perspective assumes that tensions persist within complex and dynamic systems. These underlying tensions are not only normal but, if harnessed, can be beneficial and powerful. The juxtaposition of coexisting opposites intensifies experiences of tension, challenging actors' cognitive limits, demanding creative sense-making, and seeking more fluid, reflexive and sustainable management strategies." In this section we

highlight this creative tension by drawing together the paradoxes, the theoretical propositions and the HRM priorities that each suggest (see Table 1).

As firms become more international in their reach, a natural tendency has been to develop formal knowledge exchange mechanisms and practices (Gupta and Govindarajan, 2000), supported by ever more sophisticated IT management strategies like intranet systems, social networking websites and global forums. However, as demonstrated in a study of two Danish MNCs (Gooderham *et al*., 2010), while social governance systems promote social capital and the conditions for effective knowledge transfer, hierarchical governance systems actually constrain this outcome. It stands to reason, individuals and communities will only reciprocate know-how with spatially or culturally distant parties (like newly acquired partners) when mutual trust has developed, the perceived risk of opportunistic behaviour is reduced and they are rewarded professionally for doing so. Leaving this to chance via informal socialization can lead to restrictive homogenization and even discrimination against those who do not conform to the strong norms. However, if over-orchestrated, governance systems can have a 'top-down', unidirectional feel to them, unlikely to create the conditions for an unfettered flow of tacit knowledge. The challenge for HR specialists is to pick a path between the two dysfunctional extremes and facilitate the creative tension of each paradox.

First, and running through all HRM practices, is the need to *build trust*, which is the 'behavioural lubricant' that creates flexibility and reduces conflicts between partners. Strong network ties involve greater trust and collaboration, assisting the extraction of network

TABLE 1 *The theoretical propositions and HRM priorities arising from five KM paradoxes*

KM Paradox	Theoretical Proposition	HRM Priority
the more knowledge is formally managed, the *less* likely effective knowledge exchange will occur	cultivating knowledge interdependence, peer pressure and a long-term legacy are more likely to stimulate effective knowledge exchange than formal governance systems	BUILD TRUST design-in modular structure to encourage high interdependence and build peer-group accountability create knowledge bridges based on high trust & galvanize energy and resources around the collective 'big picture'
the more democratic knowledge-exchange is desired, the *more* intentional leadership is required	collaborative leadership – with particular regard to intellectual, institutional, and political processes – will promote effective knowledge exchange.	FOCUS ON PROCESS Build-in robust attention to the process, know-how as well as know-what (*how well are we working together*?) equip leaders to work with local politics and 'mobilize bias' astutely
the more knowledgeable professionals are, the *less* likely they are able to lead	developing leadership skills to match the technical expertise of senior knowledge specialists will lead to more effective knowledge exchange	REWARD KNOWLEDGE-GENEROSITY proactively tap into the 'experts' and free up time for those who have the skills/desire to mentor and apprentice less experienced colleagues reward those who are generous with their *savior faire* and show proficiency at building internal and external networks
the more pervasive the technologies, the *more* isolated knowledge specialists can become.	promoting creative freedom in the use of technology (which distinguishes tacit from explicit knowledge) and co-locating knowledge workers results in more flexible and effective knowledge exchange	NURTURE COPs facilitate virtual communities of practice (enabled by ICT when necessary) with regular face to face contact for tacit knowledge exchange work with IT Dept. to ensure appropriate use of ICT platforms to catalyse fluid exchange of codified data
the more informal that knowledge exchange is, the *more* likely it is that discrimination will occur	celebrating the richness of social and cultural diversity (rather than ignoring or 'managing' it) will lead to the removal of barriers to knowledge exchange	ENHANCE DIVERSITY-AWARENESS focus on skills and mind-sets associated with (1) dealing with difference and stereo-typing and (2) learning the lessons from cross-cultural discomfort and conflict

resources and interactive knowledge sharing between network actors. Such a privileged access to network resources constitutes social capital (Adler and Kwon, 2002; Janowicz-Panjaitan and Noorderhaven, 2009). While IT management strategies can provide the communication platforms necessary for international flow of knowledge, HRM can influence the knowledge sharing *process* by job design which encourages interdependence (no one group can 'do it alone'), by providing building an environment of mutual trust (Li, 2005) and by generating shared goals (Chow and Chan, 2008), especially those which benefit wider society.

Second, HRM needs to *focus on the process* (as well as the task). Knowledge exchange between individuals is a shared process in which participants are constantly (re-)evaluating trust, making sense of social and institutional cues and (re-) constructing their own meanings. Social relations and power plays often distort and/or dilute directives from appointed leaders or highly rational management systems (Donnelly, 2008; Seba and Rowley, 2010). It is difficult to force the sharing of knowledge as it may be "personal, subjective, socially determined, primarily tacit and related to daily practice" (Van den Hooff and Huysen, 2009: 1). It is here that astute HRM can develop political awareness as a positive skill rather than a dirty word, especially what Buchanan and Badham (2010: 54) call the aptitude of "mobilizing bias" among colleagues.

Third, is to *nourish and reward knowledge generosity*. There are different types of knowledge network: some are based on communality or embedded interpersonal ties, some are more strategically oriented around professional and career-oriented ties and others are more task-oriented. All have a part in upgrading know-how and continuous learning. Inkpen and Tsang (2005) note that *access* to knowledge is necessary but not sufficient for effective knowledge capture and dissemination. Their central proposition is that all three dimensions of social capital (structural, cognitive and relational) are necessary and vary in their effect on knowledge exchange. While we find their reference to knowledge 'capture' has overtones of knowledge as a commodity, we see a key role here for HR specialists to build this social capital in ways which suit or match the nature of the network in which they are embedded. This is more likely to lead to a better match between exploitive and explorative learning and the time-dimension in which the firm operates (Swart and Kinnie, 2010).

Fourth, *establish communities of practice* (*COPs*). In addition to developing the exchange of codified knowledge via data management systems, HRM needs to facilitate strong ties across knowledge-intensive organizations to provide access to more finely-grained and high quality knowledge. While ICT-enabled virtual communities (perhaps in the form of web-based digital libraries and peer-to-peer technologies) have a part to play, this primarily requires face-to-face interaction for minimizing psychic distance which inhibits knowledge exchange, particularly in the case of tacit knowledge which is more difficult to identify, evaluate and absorb (Uzzi, 1997). While COPs may be virtual and spread across networks of teams in different geographies, occasional meetings are necessary for further tacit knowledge learning and to encourage reciprocity (Bahlmann *et al*., 2010). Once again this calls for 'nudge' – rather than prescriptive – leadership from HR specialists as well as working with their IT counterparts to ensure that knowledge platforms are not accompanied by cumbersome procedures, do not lead to data overload, are user-friendly and are not perceived to be surveillance mechanisms.

Finally, build *diversity-sensitive* ethos. One organizational tendency is to gloss over difference (based on gender, age, ethnicity, culture, language), another is to let prejudice and discrimination to go unchecked. Quite apart from the dubious ethics of these stances, both inhibit knowledge exchange. There is empirical evidence to suggest that the inevitable diversity-conflicts (arising from mergers and acquisitions, for example), can serve to "unfreeze the cognitive maps of senior managers, structures and processes, preserve healthy

levels of doubt, diversity and debate, create new knowledge" (Sparrow *et al*., 2004: 89). Here, the clue for HR strategists is to set up cognitively disruptive initiatives to help employees work effectively with a diverse workforce, to become more self-aware of group-based differences and to confront negative stereotyping and prejudice (Gooderham, 2007). It seems that a style of HR leadership is required that is more about creating an ethos rather than prescriptive rules.

CONCLUSION

This paper critically reviews some of the parallel literatures on knowledge exchange and international HRM and makes two important types of contribution: theoretical and practical. To do this we draw upon studies of the ATLAS collaboration. We recognize that this is, in many ways, an atypical case: the detector collaborations are initiated by self-organizing groups of like-minded senior researchers, who have a long-history of personal contacts; the organization of the particle physics detectors is inherently modular, with sub-units operating independently (so allowing for significant flexibility and decentralized management); and – as noted above – the experiment is surrounded by an organization taking care of the explicit legal, administrative and technological environment (Global Science Forum, 2010). However, we argue that these idiosyncracies are themselves points of learning for other international R&D firms and, to a more modest extent, replicable by MNCs. Closer inspection of knowledge activists in the ATLAS collaboration generates five fresh propositions which partly challenge and partly amplify current theorizing in the arena of KM. Sparrow (2006) models some specific implications for the HR function resulting from the need of global organizations to generate, capture and diffuse explicit and tacit knowledge. Here we use empirical data to propose a number of distinctive HRM priorities for those in knowledge-intensive organizations, where the effective exchange of especially tacit knowledge across international and global networks is central to their success. It has been noted that: "Big Science projects differ from companies in important ways. They are publicly financed and do not seek profits. They are one-off affairs, with no need to maintain supply-chains or manage long-term relationships with customers. Yet like companies they must innovate furiously, make the most of limited resources and beat rivals to breakthroughs" (Schumpeter, 2013). For this reason, it may be that we have more to learn about knowledge exchange from collaborations like ATLAS than we think.

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APPENDIX. SUMMARY OF ATLAS RESEARCH DESIGN

Research site

CERN, the European Organization for Nuclear Research, is one of the world's largest and most respected centers for high-energy physics. Founded in 1954, the CERN Laboratory sits astride the Franco–Swiss border near Geneva. CERN was one of Europe's first joint research ventures and now has 20 Member States. The ATLAS experiment, one of four currently being conducted using the Large Hadron Collider (LHC) at CERN, is, together with its 'sister' experiment CMS, arguably the most complex and ambitious scientific experiment ever undertaken. The ATLAS collaboration brings together over 3500 physicists working in 174 institutes located in 38 countries. Having started to operate in 2009, and discovered the Higgs boson in 2013, the ATLAS detector is searching for new discoveries in the head-on collisions of protons of extraordinarily high energy.

Research methodology

Stage 1 Mapping knowledge

Non-participant observation. During 22 visits over three years, members of the research team sat in on numerous technical briefings, presentations and project team meetings at CERN and in the UK. Notes from these meetings together with documents collected provided a more detailed context for the knowledge exchange process throughout ATLAS collaboration.

Initial exploratory interviews with nine members of the ATLAS Collaboration *and archival research*. Our objective at this stage was to obtain an understanding of the inner workings of the collaboration.

Focused interviews with members of the Trigger and Data Acquisition group (TDAQ). This group (21 respondents) was particularly appropriate because they are responsible for gathering the data coming from the different parts of the ATLAS detector, selecting those which are relevant, and storing them properly for its later analysis by members of the network worldwide.

A web-based questionnaire was was sent out to 175 members of the TDAQ community, and we obtained 74 usable responses, a response rate of 42.29%. Results helped to identify the most important knowledge domains that TDAQ users currently apply in executing their work and these were mapped into the I-Space (Boisot, 1998; Ihrig and MacMillan, 2013).

Stage 2 Perceptions of knowledge exchange

Semi-structured interviews (mainly face to face) were conducted with 55 ATLAS scientists to explore their perceptions of the way knowledge was generated, disseminated and used. Interview questions were informed by two sources: a paper on careers among knowledge workers (Kamoche *et al*., 2011) and a review of networked enterprises (Nahapiet, 2008), but follow-up questions pursued issues raised by the respondents themselves. Respondents ranged from male and female PhD students to professors of various nationality, 34 were currently

located at CERN and the remainder were interviewed at their home Institutes in the UK, Denmark and China.

Data analysis

The transcripts of all interviews were examined using template analysis (King, 2004) within a 'contextual constructivist' discourse (Madill *et al*., 2000). Three separate lines of enquiry were pursued, broadly operating within an interpretive discourse, and were published as follows:

1 how is knowledge leadership exercised and interpreted by scientists in different parts of the global collaboration and what motivates scientists to share tacit knowledge? (Mabey *et al*., 2012).
2 how is knowledge leadership enacted and experienced by ATLAS scientists? (Mabey and Nicholds, 2015).
3 how important is face to face working and to what extent does local culture attenuate the trust necessary for mutual knowledge exchange? (Mabey *et al*., 2015).

In each case, statements from the interviews were initially clustered into broad conceptual groupings, linked to the respective research questions, and then gradually broken down into subsidiary constituent themes. In this way, subjective and sometimes conflicting views were gathered from participants as to how they interpret the processes, the effectiveness and the impact of knowledge exchange in ATLAS.